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ABSTRACT

The aggregate economic value of additional education or schooling is an important research question with major policy impact. Labor market based estimates are only a portion of the total effects of education which are valued by citizens. The remaining portion consists of some additional marketed effects of education and a large number of valuable effects such as working conditions, leisure, and health which are not reflected in market prices. The first part of the paper discusses the economic character of 20 marketed and non-marketed effects of education and summarizes what is known from existing literature regarding the magnitude of impact and economic value of each effect. The second section outlines a method for measuring the marginal value of education, covering both market and non-market impacts. Illustrative calculations are provided in the third and final section. It is concluded that the standard rate of return estimates of the benefit of incremental schooling may capture only about three-fifths of the full (market plus non-marketed) value of education. (Author/RM)

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Education and Economic Well-Being: The Role of Non-Market Effects

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ABSTRACT

The aggregate economic value of additional education or schooling is an important research question with major policy impact. A portion of this aggregate value has been measured by economists, and is reflected in widely circulated estimates of the rate of return to education. These rate of return estimates are based on the impact of education on the lifetime labor market earnings of the person educated, and appear to be smaller in recent years than in prior periods. This decline has prompted claims that Americans are being "over-educated," and has been used to justify reduced expenditures on schooling.

A major point of this paper is that these labor market based estimates are only a portion of the total effects of education which are valued by citizens. The remaining portion consists of some additional "marketed" effects of education and a large number of valuable effects which are not reflected in market prices. These non-market effects consist of the contribution of education to such aspects of individual well-being as fringe benefits, working conditions, leisure, quality of children, health, and consumption efficiency. The effects may also be in the nature of public goods--crime reduction, social cohesion, technological change.

In the first section of the paper we discuss the economic character of twenty marketed and non-marketed effects of education and summarize what is known from existing literature regarding the magnitude and value of each effect. The second section presents a method for measuring the marginal value of education's contribution to marketed and non-marketed effects. This technique rests on production function relationships and

the values of inputs which are implicit in empirical estimates of these relationships. In the last section we illustrate the potential of this procedure by estimating the willingness to pay of individuals for a variety of the non-market benefits of an additional year of schooling. Using empirical estimates of the effects as they have appeared in the literature, we conclude that standard rate of return estimates of the benefit of incremental schooling may capture only about three-fifths of the full (marketed plus non-marketed) value of education.

Education and Economic Well-Being: The Role of Non-Market Effects

> "Of late, economists have been spending considerable time attempting to assess the economic contribution of education."
>
> William Bowen, 1964

While Bowen's claim is as true today as two decades ago, the nature of economists' efforts in this area has changed substantially. The work of the early 1960s that Bowen had in mind focused on assessing the contribution of schooling to individual productivity (as measured by observed earnings increments; see, Becker, 1964; Hansen, 1963; Mincer, 1974) and to aggregate economic growth (as measured by national income; see Denison, 1962). Since, then, however, the emergence of two major emphases in economics has altered the nature of the question regarding education's effects. First, the real welfare effects of economic changes are now seen as inhering primarily in individual utility functions, and as being measured by indices of utility change based on Hicksian variations. Second, in part because of this focus on utility changes, external and other impacts of economic changes not reflected in markets have received increased attention. Although early analysts recognized well that changes in observed earnings and output did not capture all of the relevant economic effects of schooling, few concerned themselves with the wide range of non-market impacts of education that were emphasized in the 1970s and 1980s by the "new welfare economics" and the "new home economics."[1]

This paper focuses on these non-market effects of education.[2] In Section I, we briefly discuss the economic character of these effects,

and characterize the most prominent of the non-market impacts of education identified in the recent literature (see also Michael, 1982). An overview of the general findings concerning these impacts is also presented. While research has often identified the sign of the impacts of education and, in some cases, measured its effect on relevant quantities, little is known about the willingness to pay for--the real welfare impact of--these changes. Section II describes a procedure for imputing the benefits of these non-marketed effects from estimates of quantitative impact. The assumptions required for such imputations to be reliable are strong, and they are identified. Finally, in Section III, we indicate the potential of this procedure by showing the willingness to pay for a variety of non-market effects of education, as implied by empirical estimates in published research.

I. THE NON-MARKET EFFECTS OF EDUCATION

> "By sowing seed, you will harvest once. By planting a tree, you will harvest ten-fold. By educating the people, you will harvest one-hundred-fold."
>
> Kuan-tsu, China,
> 4th-3rd Century, B.C.E.
> (Cited in Cohn)

Private goods for which consumption is exclusive are rare. Those for which consumption is non-exclusive but of insufficient magnitude to warrant collective action are far less rare. Schooling falls in neither category. For both efficiency and equity reasons, schooling (especially at the elementary and secondary levels) has been largely reserved to the public sector. Moreover, the output of the schooling activity is

distributed to individuals at a zero price or one far below marginal cost (except perhaps in some private institutions). To the extent that any market exists for schooling services, the observed price provides little indication of the willingness of beneficiaries to pay for the marginal unit provided.[3]

The quantity of schooling provided depends on public policy choices, which in turn require evaluation of the marginal benefits and costs of schooling. Any reliable estimate must consider the full set of benefits and costs attributable to schooling, both the marketed (and, hence, relatively easy to measure) effects and those that are non-marketed and unrecorded--private effects and those with public good characteristics.

Most estimates of the social payoff to additional schooling have been limited to effects which are marketed, and for which an impact can be recorded. The labor market impacts of education in the form of earnings increments have been emphasized in the human capital literature, and form the primary estimates of the impact of incremental schooling most often referred to in policy discussions. Marginal rates of return, reflecting increments to market earnings attributable to education, have been estimated and reported. [9]

As a guide to policy choices, the benefit-cost ratios (or marginal rates of return) estimated from earnings effects have limited value. To the extent that schooling generates other impacts valued by people but not recorded in earnings differences, the standard rate of return estimates yield biased estimates of the value of incremental schooling. A full accounting must consider all of education's effects, positive and negative, and not simply those recorded in a single market. The purpose

of this section is to provide a comprehensive catalogue of the effects of schooling which have been reported in the literature, to indicate the economic character of each effect (exclusive, externality-generating, or public; marketed or non-marketed; consumption or investment), and to summarize what is known from the literature regarding the quantitative magnitude of the impact and its value. Table 1 summarizes this information.

The productivity-increasing effect of education emphasized in the human capital literature is shown as item 1 in this table. In addition to inducing labor earnings differentials, schooling explains differences in non-wage remuneration in the form of fringe benefits and working conditions (item 2). Some of those impacts would be easily captured in rate of return estimates if appropriate microdata were available. Through its effect on wage rates (and income), schooling induces changes in the value of leisure [and, perhaps, the quantity of it chosen (item 3)]. To the extent that the wage rate change induced by schooling reflects the value of both incremental and infra-marginal leisure hours, economic well-being will tend to increase from this source as well. Evidence concerning the effects of schooling on further schooling of the individual suggests that the productivity in producing human capital is increased by additional schooling (item 4). The discussion on this issue concerns the extent to which schooling is technologically neutral in determining the productivity of time used in the labor market versus time used in producing additional schooling. While the unit value of time spent in home activities [for example, do-it-yourself projects (item 5), intra-family relations (item 6), and child care (item 7)] may increase

Table 1

Catalogue of Impacts of Schooling, Nature of Impacts, and Evidence on Magnitude of Level and Value of Impact

Channel of Impact of Schooling	Economic Nature of Impact	Nature of Existing Research on Magnitude of Impact	Status of Economic Benefit Estimates
1. Individual Market Productivity	Private; marketed; human capital investment	Extensive research on the magnitude of market earnings impact, by demographic group and type of schooling (Schultz, 1951; Hansen; Becker, 1964; Mincer, 1962; Hanoch; Griliches and Mason; Conlisk)	Increments to marginal value products, reported as rates of return. Producers' surplus neglected
2. Non-Wage Labor Market Remuneration	Private; marketed and non-marketed; human capital investment	Some research on differences in fringe benefits and working conditions by education level (Duncan; Lucas; Freeman, 1978)	Rough estimates of true returns to schooling 10 to 40 percent greater than rate of return estimates indicate
3. Leisure	Private; non-marketed; consumption	Wage rate differences identified in 1. form shadow prices which could be used to value leisure, but seldom are (Psacharopolous; Behrman, Wolfe, and Tunali)	
4. Individual Productivity in Knowledge Production	Private; non-marketed; human capital investment	Some evidence that schooling increases productivity in the production of additional human capital (Ben-Porath, 1967, 1970; Rosen)	No firm evidence on the extent of value
5. Non-Market Individual Productivity (e.g., do-it-yourself)	Private; non-marketed; human capital investment	Some evidence of education-induced reduction in female home production time, but increase in quality; no evidence for males.	No estimates of economic value
6. Intra-Family Productivity	Private; some external effects; both marketed and non-marketed; human capital investment	Relationship between wife's schooling and husband's earnings, apart from selectivity, is well-established (Benham)	id.

(table continues)

Table 1 (cont.)

Channel of Impact of Schooling	Economic Nature of Impact	Nature of Existing Research on Magnitude of Impact	Status of Economic Benefit Estimates
7. Child Quality through Home Activities	Private; some external effects; both non-marketed and marketed; human capital investment	Substantial evidence that child quality in several dimensions (health, cognitive development, education, occupation status, future earnings) is positively and significantly related to mother's and father's education (Leibowitz, 1974, 1975; Edwards and Grossman; Birch and Gussow; Hill and Stafford, 1974, 1980; Wolfe and Behrman; Sewell and Hauser; Lindert; Murnane; Schultz, 1975; Taubman; Wachtel)	No significant evidence of economic value except intergenerational earnings effects (Swift and Weisbrod; Spiegelman)
8. Own Health	Private; modest external effects; partially marketed; human capital investment and consumption	Evidence that own and spouse's schooling positively and significantly affects health status and, on an aggregate level, that more education decreases mortality (Fuchs, 1974, 1978; Feldstein; Leigh; Grossman; Orcutt; Lee)	Little evidence on economic value; except indirect evidence via earnings, weeks worked, and life expectancy
9. Spouse and Family Health	Private (within household); modest external effects; partially marketed; human capital investment and consumption	id. (Auster, Leveson, and Sarachek; Rosensweig and Schultz; Grossman; Grossman and Jacobowitz)	id.
10a. Fertility (viz., attainment of desired family size)	Private (within household); non-marketed; consumption	Research on contraceptive use and techniques suggests that efficiency in contraceptive use and attainment of desired family size is related to education (Michael, 1973; Ryder and Westoff; Michael and Willis; Rosensweig and Seiver)	No estimates of economic value

(table continues)

Table 1 (cont.)

Channel of Impact of Schooling	Economic Nature of Impact	Nature of Existing Research on Magnitude of Impact	Status of Economic Benefit Estimates
10b. Fertility (viz., changed tastes for children)	Private (within household); some external effects; non-marketed consumption	Evidence suggests that schooling reduces desired family size (Mincer, 1974; Becker, 1974; Willis; Michael, 1973; Birdsall; Easterlin)	No estimates of economic value; perhaps impossible given nature of taste change, except through influence on economic growth
11. "Entertainment"	Private; non-marketed; consumption	Education appears to be consumed for its intrinsic value, and possibly to broaden forms of entertainment enjoyed (Lazear)	id.
12. Consumer Choice Efficiency	Private; some external effects; non-marketed; human capital investment	There is evidence that education alters budget allocations in the same direction as income, implying the existence of positive efficiency effect (Michael, 1972; Pauly; Schultz, 1975; Hettich)	No estimate of the value of increased efficiency
13. Labor Market Search Efficiency (incl. migration)	Private; some external effects; non-marketed; human capital investment	Some evidence that job search costs reduced with improved information and knowledge, and job and regional mobility increased (Greenwood; Metcalf; DaVanzo; Schwartz; Mincer, 1978; Friedlander)	id.
14. Marital Choice Efficiency	Private; minor external effects; non-marketed; consumption	Some evidence of improved sorting in the marriage market and positive assortative mating by intelligence (Becker, Landes, and Michael; Jensen)	id.
15. Crime Reduction	Public good	Evidence that education is, ceteris paribus, positively associated with reduced criminal activity (Ehrlich)	No estimates of economic value

(table continues)

Table 1 (cont.)

Channel of Impact of Schooling	Economic Nature of Impact	Nature of Existing Research on Magnitude of Impact	Status of Economic Benefit Estimates
16. Social Cohesion	Public good	Impressionistic evidence of a positive relationship with education (Campbell et al.; Gintis)	id.
17. Technological Change	Public good	Limited evidence that education influences economic behavior in terms of research and development (Nelson; Mansfield; Huffman, 1974, 1977)	id.
18. Income Distribution	Public good	Evidence on the direction of impact of education on income inequality is mixed (Mincer, 1974; Chiswick; Marin and Psacharopoulos; Tinbergen; Dresch; Jencks)	id.
19. Savings	Private; some external effects; marketed productive factor	Holding constant income and other savings determinants, education appears to be positively associated with saving rates (Solmon)	id.
20. Charitable Giving	Both private and public; non-marketed	Evidence that education increases both money and time donations (Mueller; Dye)	id.

because of education, the amount of time spent on these activities may decline.[4] The net effect of education on these home-related activities—some of which are ultimately marketed (e.g., by increased spouse or child's earnings capacity) and some of which spill over onto the community generally (e.g., improved citizenship of children)--is not known with confidence. Although education may decrease the amount of time spent on home activities (e.g., child care) while simultaneously increasing its unit value, a number of studies (for example, Leibowitz, 1975) indicate an increase in both variables.

The effect of education on own and family health (items 8 and 9) is positive because of its effects on information, occupation, location, and medical care usage. Only to the extent that such effects result in higher wage rates or more hours worked will they be reflected in market earnings. Moreover, to the extent that better health has externalities (reducing contagious disease or influencing the utility of others), some of the benefits of improved health will spill over onto the community.

While the evidence indicates a positive effect of education on producing further human capital (job training, own health, and household production in its many facets), these results must be interpreted with caution. First, if there were a large scale increase in resources devoted to education, some of the rates of return would probably decrease (Bowman, 1966). Second, to the extent that variables such as ability or farsightedness contribute to <u>both</u> education <u>and</u> further production of human capital and are unobserved and unmeasured in the estimates in the literature, the effects attributed to education will be overestimated (Fuchs, 1974; Rosen and Willis, 1979). A corollary of this is that if,

say, individuals with higher ability are self-selected into more education, observed marginal returns to education will overstate the true effects of incremental education not distributed according to these selection criteria.[5]

Education both changes tastes for children and, through providing information and superior planning skills, enables closer approximation to desired family size (items 10a and 10b). While the evidence suggests a reduction in family size attributable to education's impact on the value of time and tastes, it is difficult to set an economic value on behavior changes induced by an alteration of tastes. Evidence also suggests that, apart from taste changes, education enables a family to attain its desired family size--a definite positive effect of education on economic well-being. No evidence on the willingness of individuals to pay for such effects exists, however. Moreover, it should be noted that a portion of the education-induced changes in desired family size is external to the family if population growth rates are non-optimal, or if the social welfare function is not individualistic.

The process of education is, for many, an enjoyable experience, and one for which some willingness to pay exists (item 11). Moreover, to the extent that the choice of school attendance allows one to avoid undesirable options (e.g., military service), a further positive contribution to well-being exists. Education is also asserted to change tastes, increasing the enjoyment of "meritorious" consumption activities--reading, music, art. Again, evaluation of the contribution to economic well-being of such taste changes is problematic.

Items 12, 13, and 14 relate to the contribution of education to the efficiency of choices (matches) in the consumption, labor, and marriage markets. The contribution of education in the form of information, facts, and ideas enables better-educated persons to make consumption choices more efficiently, implying a reduction in the time and other resource costs of undertaking the same home tasks. Evidence suggests that incremental education shifts consumer budget allocations in much the same way as does income, hence contributing to household well-being as does incremental income. There is also evidence that education reduces non-optimal consumption such as physician-induced demand for medical care visits. In much the same way, education is likely to contribute to the effectiveness with which available workers with constellations of skills become matched to jobs with their skill requirements. Education is also likely to increase job and regional mobility. The reduction in transactions costs associated with reduced search time is a real economic benefit, which in the implicit markets established between buyer and seller becomes shared by them in some proportion. It has been suggested that education improves selection and sorting in the marriage market and there is evidence of positive effects in this area. Again, no estimates of the value of these education-induced contributions to well-being are available, although the role of education itself has been estimated.[6]

Reductions in criminal activity (item 15), increases in social cohesion and technological change (items 16 and 17), and improvements in the income distribution (item 18) have all been credited to increases in education. All of these effects have public good characteristics in that changes at issue are, simultaneously, arguments in the utility functions

of numerous individuals; the effects are clearly non-exclusive. Evidence on the effects of education on these variables is scanty, but suggests a positive impact on crime reduction, social cohesion, and technological change. Evidence on whether education has an equalizing or disequalizing effect on the income distribution is mixed.[7] The well-being effects of increments to all non-exclusive outputs are largely unknown; those stemming from education are no exception.

Education is also seen as contributing, ceteris paribus, to increased savings (item 19), conveying both increased individual security and external benefits if aggregate saving is less than optimal. While the secondary market for loanable funds provides evidence that any savings increment has private value, the wedge between the supply and demand price for savings makes estimation of external benefits difficult. Again, no attempt to derive an estimate of the economic value of this effect of education is in evidence.

Finally, education is viewed as increasing charitable giving (item 20), in terms both of money and time. These have both a private gain in terms of utility from the donation of resources and a potential social gain depending on who receives the benefits; the distributional consequences include the cost of foregone taxes.

In sum, then, the economic benefits of education occur through numerous channels. For some of these "outputs," prices and outputs in secondary markets provide some estimate of the willingness to pay for education benefits. Other outputs are not marketed, though directly consumed. Still others spill over to persons beyond the direct recipient or are close to classical public goods. Our review of the evidence leads to

the following conclusion for some of these indirect effects: Education tends to reduce completed family size. This is partly explained by the increased ability to achieve desired family size through more efficient contraceptive use. In addition, education leads to increased efficiency in producing higher quality children (in terms of health, intellectual development, and earnings capacity). Since the utility from children (according to the new home economics) comes from child quality--and more education and better health lead to higher quality--a reduction in the quantity desired may result. Education also leads to greater efficiency in consumption and, hence, greater utility through improved market expenditures. The efficiency of labor and marriage market operation is increased, migration is made with more information and is more successful, job and mate search costs are reduced, and superior implicit contracts attained. Still further, available evidence suggests that education improves own health and earnings and spouse's health, and decreases expected mortality. To the extent that these utility-increasing or cost-reducing effects are beyond wage increases, they are not captured in standard estimates of the benefits of education. There is also some evidence that crime may be reduced due to increased education.

Finally, evidence on the effect of education on the income distribution is mixed. Evidence on other effects of education such as social cohesion, leadership, and the speed of technological diffusion is speculative or non-existent. Moreover, estimates of the willingness to pay for those quantity changes that have been uncovered have not been attempted. One is left with the strong impression that education yields

true economic well-being benefits which are substantially larger than those captured in estimates of direct rates of return to labor market activities. Any full benefit-cost appraisal must encompass all of these impacts. In the following discussion, we will propose and illustrate a procedure for measuring the value of those impacts of education which are typically ignored in discussions of education's net social value.

To our preceding discussion of the non-market effects of education, we offer two caveats. First, our discussion focused on those impacts of education for which evidence exists in the literature. Other impacts may also exist, and many of these may not be benefits. Speculation on the contribution of education to marital instability, job related stress, destructive social protests, alienation, and feelings of anomie is common, and such costs might also be chargeable to education's account. No evidence on these relationships is available, however. Second, our discussion—in part by equating education and schooling--has suppressed the importance of heterogeneity in the schooling services provided. Not all units of schooling yield the same impacts; any particular type of schooling may have different impacts on different types of students; and evidence exists that in many cases what passes as education may be misplaced, misleading, and a useless drudgery. Efforts to estimate education's impacts must recognize this need to distinguish among the wide variety of activities which pass as schooling in order to reflect this heterogeneity (Summers and Wolfe, 1977).

II. ON ESTIMATING THE VALUE OF THE NON-MARKETED EFFECTS OF EDUCATION

> "A good education confers great indirect benefits even on the ordinary workman. It...raises the tone of his life in working hours and out of working hours."
>
> A. Marshall,
> Principles of Economics, 1890

The catalogue of economic impacts described in Table 1 suggests that rate of return estimates based on education-related earnings differences may capture but a fraction of the aggregate contribution of education to economic well-being. Hence, there is a need for some means of identifying the value to recipients of the non-market contributions of education, and the incorporation of these impacts into a full benefit-cost appraisal of education's effects. In this section, we briefly outline a method for measuring the marginal value of education, covering both market and non-market impacts. This method will, in turn, suggest a procedure for estimating the value of those effects for which no ready market measure is available.

Ideally, a demand function could be estimated for homogeneous units of education, conditioning on a series of socioeconomic variables. Such a function would yield estimates of the willingness to pay for education which would capture both marketed and non-marketed impacts. In the absence of such a measurement, a single point on the function (without controlling for socioeconomic characteristics) may enable a crude estimate of marginal value to be made. Since an individual's level of education is known, an estimate of that individual's cost of education locates

a single point on the demand schedule for education. This estimated cost equals the marginal benefit of education at its existing level.

Consider education to be an input to several household production functions. The outputs of these production functions--which directly yield utility--include health, social acceptance, "high quality" children, and greater wage income, among other things. Consistent with household production theory, assume, first, that consumers, acting as firms, efficiently combine market goods so as to yield a consumption frontier for produced goods that enter their utility functions. Second, consumers maximize utility subject to this consumption frontier.

Employing only the first (cost minimization) stage, a value for education can be inferred. Let the production function of good j ($j = 1,\ldots,N$) be denoted by $Q_j = f_j(Z_{j1},\ldots,Z_{jr}, X_M)$. $X_1,\ldots,X_M$ are non-exclusive inputs that enter all production functions simultaneously such that the total amount of the factor is available to each f_j. The level of education, which enters several f_j without being depleted by any of its uses, is an example of such an input. $\tilde{Z}_{jr}$ ($r = 1, \ldots, R$) denotes the amount of conventional (or exclusive) inputs, Z_r, that enter f_j. The aggregate amount of any Z_j must be apportioned among the N production functions such that $Z_r = \sum_{j=1}^{N} Z_{jr}$ for $r = 1,\ldots,R$.

If W_r represents the price of factor Z_r and P_m the price of factor X_m, the total cost of production for the set of goods $j = 1, \ldots, N$ is

$$C = \sum_{m=1}^{M} P_m X_m + \sum_{r=1}^{R} W_r Z_r, \text{ and the Lagrangian for cost minimization is}$$

$$\pi = \sum_{m=1}^{M} P_m X_m + \sum_{r=1}^{R} W_r Z_r + \sum_{j=1}^{N} \lambda_j [Q_j - f_j(Z_{j1}, \ldots, Z_{jr}; X_1, \ldots, X_M)].$$

Since the choice variables are $X_m (m=1, \ldots, M)$ and $Z_{jr} (j=1, \ldots, N)$, the following standard first order conditions can be derived.

$$\frac{\partial \pi}{\partial X_m} = P_m - \sum_{j=1}^{N} \lambda_j \frac{\partial f_j}{\partial X_m} = 0 \qquad m = 1, \ldots, M \tag{1}$$

$$\frac{\partial \pi}{\partial Z_{jr}} = W_r - \lambda_j \frac{\partial f_j}{\partial Z_{jr}} = 0 \qquad j = 1, \ldots, N \text{ and } r \ni Z_{jr} \in \tilde{Z}_j \tag{2}$$

where $\tilde{Z}_j$ is the set of Z_{jT}, $T \subseteq \{1, \ldots, R\}$, for which the optimal use is not a corner solution at zero.

(2) implies that $\frac{W_s}{W_q} = \frac{\partial f_j / \partial Z_{js}}{\partial f_j / \partial Z_{jq}}$ $\forall_j$ and $Z_{js}, Z_{jq} \in \tilde{Z}_j$;

(1) implies that $P_m = \sum_{j=1}^{N} \lambda_j \frac{\partial f_j}{\partial X_m}$. But, from (2), $\lambda_j = W_r / (\partial f_j / \partial Z_{jr})$ for $j = 1, \ldots, N$ and $r \ni Z_{jr} \in \tilde{Z}_j$. That is, λ_j equals the ratio of the wage to the marginal product for any factor Z_k that appears in f_j in positive amounts. If some Z_r appears in positive amounts in all f_j, then

$$P_m = \sum_{j=1}^{N} W_r \left[\frac{\partial f_j / \partial X_m}{\partial f_j / \partial Z_{jr}} \right] . \qquad (3)$$

Hence, the marginal value of education can be derived from estimates of the marginal cost of education implicit in observed input prices and measured marginal products.

The derivation of education's aggregate marginal value is also possible even if no Z_r appears in positive amounts in all f_j. For example, choose any Z_{r_1} that appears in f_1, and any Z_{r_2} that appears in f_2, ..., and any Z_{r_N} that appears in f_N, where $r_1, \ldots, r_N \quad \{1, 2, \ldots, R\}$. In this case, (2) implies that $P_m = \left[\sum_{j=1}^{N} W_{r_j} \frac{\partial f_j / \partial X_m}{\partial f_j / \partial Z_{j,\, rj}} \right]$. Therefore, if X_m enters $(N - L)$ f_j, P_m can be derived from the prices and marginal products of any set of $(N - L)$ or fewer factors such that at least one of these factors appears in each of the $(N - L)$ production functions. For example, if Z_6 appears in f_1 and f_2 but not f_3, and if Z_9 appears in f_2 and f_3 but not f_1, we could have $W_6 \left[\frac{\partial f_1 / \partial X_m}{\partial f_1 / \partial Z_{1,6}}\right] + W_6 \left[\frac{\partial f_2 / \partial X_m}{\partial f_2 / \partial Z_{2,6}}\right] + W_9 \left[\frac{\partial f_3 / \partial X_m}{\partial f_3 / \partial Z_{3,9}}\right]$.

This approach requires no assumptions concerning the form of $Q_j = f_j(\tilde{Z}_j, X_1, \ldots, X_M)$--any production function including education yields (1), (2) and the resulting expression for P_m. Several assumptions are required for estimation, however. Since cost minimization is the first stage of utility maximization, we must first assume that consumers maximize utility. Second, the consumer must be free to choose any

X_m and Z_{jr}, including education. If there are additional variables X_s, s = M+1, ..., S and Z_u, u = R+1,..., U that are constrained, we nonetheless want the marginal conditions to hold for X_m and $Z_{jr} \in \tilde{Z}_j$. While constrained variables generate fixed costs, the marginal conditions for cost minimization do not depend on the absence of such constraints. Third, there must exist at least one exclusive factor that can be found in each f_j on which the estimation will rest.

Although only these assumptions are required to justify our expression for P_m, its interpretation hinges on two other assumptions. First, for P_m to be reliable, the estimates of the relevant input prices and marginal products must be consistent. And, for P_m to be the social value of X_m as well as its private value, X_m must not be a public good. Since education is clearly nonexclusive in some of its impacts, the estimate of the marginal value of education derived above will understate its full social value.

III. VALUING THE NON-MARKET EFFECTS OF EDUCATION: SOME ILLUSTRATIVE CALCULATIONS

> "The impressive ingenuity of researchers in estimating such seemingly immeasurable concepts as utility-based marginal rates of substitution suggests that where there is a will there is an estimate."
>
> Michael, 1982

Section II outlined a procedure for estimating the marginal value of education arising from its contribution to any specified non-marketed output (Q_v). In equation (3), on which we will rely in our calcula-

tions, the marginal value of education (P_m) in generating a particular non-marketed output (Q_v) depends upon the marginal contribution of education (X_m) to Q_v ($\partial f_v/\partial X_m$), the marginal contribution of some exclusive input (Z_r) to Q_v($\partial f_v/\partial Z_r$), and the observed price of Z_r(W_r). That is, from (3),

$$P_m = W_r \frac{\partial f_v/\partial X_m}{\partial f_v/\partial Z_r}. \qquad (4)$$

This approach embodies the proposition that, with producers (largely home producers) in competitive equilibrium, the unit value of a non-marketed input to the production of Q_v is equal at the margin to the unit cost of another input which is privately purchased and non-joint and which yields an equivalent increment to the output of Q_v. This proposition, in turn, derives directly from the proposition that competitive producers in equilibrium will equate the ratio of the marginal product to input price, across all inputs.

To implement the approach based on (4), we require estimates of the non-market effects of education from empirical production function estimates which contain both an estimate of the marginal effect of some privately purchased, non-joint input on some non-marketed output (such as own health or child quality) and an estimate of the marginal effect of education on that same output. These two marginal product estimates, in conjunction with the estimated cost of the privately purchased input, allow us to tease out an estimate of the implicit willingness to pay for an increment to education, in its role as contributor to this non-marketed output.

Consider the following example: In the literature, an own health production function contains visits to a private physician and years of education as two, among several, inputs. The contribution of each physician visit is estimated to be one unit of own health. Each visit has a private cost of $30 and, hence, an equilibrium willingness to pay value of $30. An incremental year of schooling is estimated to add 5 units of own health. In equilibrium, then, the consumer would be willing to pay $150--$30 x 5--for the additional year of education in its role as contributor to own health.

In Table 2, we present a set of suggestive estimates of the value of an additional year of education, in its role as a contributor to a selection of the non-marketed outputs described in Table 1. These estimates are from calculations based on (4), using numerical values from production function estimates reported in the literature. Three estimates are provided of the value which people place on the contribution of one more year of parental education to the increased cognitive development of one of their children (item 7 in Table 1). This value ranges from $300 (Murnane) to $1,800 (Edwards and Grossman, 1979) and is based on the marginal contribution of family education. The divergence in the estimates is attributable to differences in the time period of the estimate (one year versus long-run measures), the population and the year to which the estimates apply, the achievement test used to measure cognitive development, and model specification. In each of these estimates, the private input is taken to be non-market work time, which is valued at the prevailing individual wage rate. Hence, in these and a number of the

Table 2

Estimates of the Value of an Additional Year of Education in Producing Selected Non-Marketed Outputs

Non-Marketed Output	Private Input Used for Imputation	Value of One More Year of Education	Study
Cognitive development of children			
1.	Family income	$1,500[a]	Shakotko, Edwards and Grossman
2.	Family income	$1,800[b]	Edwards and Grossman (1979)
3.	Family income	$ 300[c]	Murnane
Contraceptive use	Husband's predicted income	$ 360[d]	Michael and Willis
Consumption efficiency	Household income	$ 100	Michael (1975)
Criminal apprehension[e]	Per capita expenditure on police	$ 60	Ehrlich
Charitable contributions	Adjusted household income	$ 970[f]	Dye
Improvement in own health	Total net family income from assets	($3,075)[g]	Lee

[a]Mean of the estimated value of mother's and father's education, dynamic model, found in Table 3 of the study. The static cross-section estimates yield an estimated mean value of $3,223. The dynamic estimates are preferred by the authors of this paper, as they control for prior cognitive development, taken as a proxy for ability (genetics). The measure of cognitive development is WRAT2, a standardized reading and arithmetic achievement test; the sample is children 6-17 from Cycles II and III of the Health Examination Survey.

[b]Mean of the estimated value of mother's and father's education, evaluated at mean family income as reported in Table A3. From the lowest to the highest income level, the imputed value of education, using father's income, is $1,154 to $10,819. Using mother's education, the value of education ranges from $782 to $7,334. The measure of cognitive development is WISC, a standardized IQ test; the sample is children 6-11 from Cycle II of the Health Examination Survey.

(table continues)

Table 2 (cont.)

[c]Estimated from the coefficient on mother's education, taken from Table 1. The measure of cognitive development is a one year increment as measured by the Iowa Test of Basic Skills; the sample consists of children in grades 3-6 whose families were part of the Gary Negative Income Tax Experiment.

[d]Mean of the estimated value of wife's education over 1st, 2nd, and 3rd periods (intervals) between the pregnancies.

[e]The non-marketed output is the probability of convicting and imprisoning offenders, taken to be a contribution to crime reduction. Education is the mean education level in the community.

[f]Estimated from a dummy variable education specification distinguishing between college graduation and non-graduation. Based on estimates of the average level of education of those with and without a college degree.

[g]This output is in parentheses because it is only partly non-marketed. It is estimated from the coefficients on education and total net family income from assets (in thousands) in Table 4, final stage 'corrected' estimates (column 3). The data used are from the National Longitudinal Study's survey of men 45-59 in 1966.

other Table 2 examples, some variant of earned income is employed as the privately purchased input.[8]

The value of education's contribution to the attainment of desired family size and child spacing (item 10a in Table 1) is proxied by the marginal impact of education on the use of birth control. The notion is that education conveys valued knowledge regarding the net benefits of alternative numbers of children, the timing of their births, and the means of achieving desired levels of these effects. The value of this knowledge, using husband's predicted income as the basis of the estimate, is nearly $400 (Michael and Willis, 1976). This value, it should be noted, does not reflect the unknown negative health effects associated with contraceptive use; rather, the health effects are appropriately viewed as another independent contribution of education.

The third estimate in the table is that placed on the contribution of an additional year of education to an individual's (or household's) efficiency in making consumption decisions (item 12 in Table 1), an effect emphasized in work by Michael (1973). This value is estimated to be about $100, and is taken from Michael's estimates.

The next estimates are for the value of education in its contribution to two non-exclusive outputs--reductions in criminal activity and increases in charitable contributions. The reduction in criminal activity (item 15 in Table 1) is proxied by the probability of criminal apprehension and imprisonment; the value of education's contribution to this result is estimated to be less than $100. This estimate is based on cross-section data on the choices of political jurisdictions, and hence requires an assumption that these decision-making units are also cost

minimizers. The input on which the estimate is based is per capita expenditures on police, and education is measured by average educational attainment in the jurisdiction. This implies that the aggregate community value of the reduction in criminal activity attributable to an increase of one year in community education is the estimated amount multiplied by the number of members of the community.

The estimated value of education as it contributes to increases in charitable giving (item 20 in Table 1) requires the additional assumption that $1 of increased contribution yields donor plus third-party (including distributional) benefits of $1. With this assumption, the value of education's contribution to this non-exclusive output is nearly $1,000.

The final estimate, that for the value of own health (item 8 in Table 1), requires a somewhat different interpretation from the others, in that own health has both earnings (marketed) effects and well-being effects which do not pass through a market. The $3,000 figure is an estimate of the value of education's contribution to both types of own health effects. To the extent that standard estimates of the earnings differences of education include the indirect earnings effects of education operating through own health, adding the $3,000 to the standard estimates would involve some unknown amount of doublecounting. As a corollary, the portion of the $3,000 which is not reflected in earnings differences--and, hence, non-marketed--is unknown.[9]

These estimates, then, are suggestive of the economic value of education as it contributes to outputs not accounted for in standard rate of return estimates of the benefits of education. By and large, these esti-

mates seem reasonable and suggest that the non-marketed outputs of education are valued highly. Interpretation of these estimates must be cautious, however, as the assumptions on which they rest are stringent ones. The coefficients from production functions on which we have based the estimates must be without biases from simultaneity problems, unobserved variables, and other misspecifications. The household decision-makers represented in the data must be utility-maximizers free to vary each of the relevant inputs continuously, and in equilibrium. The private marketed input must be non-joint in household production and traded at a full marginal cost competitive price by knowledgeable consumers. In a variety of respects, these requirements may be violated in the studies on which we rely.

If the non-marketed outputs of education which we have selected from Table 1 are representative of those included there, we suggest that standard estimates of the benefits of incremental education may capture only about three-fifths of the full (marketed plus non-marketed) value. A conservative aggregation of the benefits for the six non-marketed outputs of Table 2 is $3,000. These six are one-third of the non-marketed items of Table 1, suggesting a total non-marketed value of $9,000, if these are representative. Hansen's (1963) estimates indicate a 1975 value of $15,000 for the marketed, earnings-based, effects of education,[10] implying a total incremental benefit of, say, $25,000.

While suggestive, these estimates are tentative. They do however, illustrate the feasibility of our proposed procedure for estimating the value of the non-marketed exclusive and non-exclusive outputs of education. They suggest that the total value of these effects constitutes an

amount which might well rival the "benefits" of education included in standard rate of return calculations. And they call for additional research on the determinants of the valued, though non-marketed, aspects of economic well-being to which education may contribute. As for their policy implications, they provide a reconciliation of the continued high levels of investment in education in the face of falling calculated rates of return (Freeman, 1976). The implied misallocation of resources by individual consumers may instead reflect a miscalculation by economists.

NOTES

[1]Weisbrod (1964) is a notable exception.

[2]Although we often refer to "education" in this paper, the analysis by and large concerns the effects of measured years of school attendance--"schooling."

[3]Under certain, rather extreme conditions, however, observed marginal costs of schooling might proxy for the marginal willingness to pay.

[4]The impact of education in changing the value of activities undertaken in hours not spent in market work (e.g., do-it-yourself and child care activities) must be distinguished from education's impact on the value of leisure time itself (item 3) if double counting is to be avoided.

[5]We are grateful to Jacob Mincer, whose comments emphasized this point.

[6]In all of these cases, it it the effect of education's contributions to these impacts over and above the levels which would be attained with the skills and "smarts" accumulated in non-school activities.

[7]Marin and Psacharopoulos (1976) explain the divergence of these findings according to whether or not researchers permit the rate of return to vary with the level of schooling. Those allowing for such dependence generally find that increases in education reduce inequality; those who assume independence find a disequalizing effect of education.

[8]To the extent that hours of time spent in producing, say, child quality simultaneously yield increments to, say, own health, or do-it-yourself production outputs, our suggestive estimates of the value of education's contribution to child quality would be biased upward.

[9]An extension of our approach could attempt to subtract from the $3,000 figure an estimate of the measured human capital (earnings) effects of education which reflect the indirect effect of education on earnings operating through health improvements, yielding a residual estimate of the value of the non-marketed effects of education on own health.

[10]Hansen estimates that the present discounted value (at a 3 percent rate) of one additional year of education to a student in his/her junior or senior year of high school to be $5,000 in 1950. Adjusting by the 1950-1975 change in the Consumer Price Index, and assuming a rate of productivity growth of 2 percent per year over the period, this yields a value in 1975 of nearly $15,000.

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